

WAR DEPARTMENT PAMPHLET • No. 8-8

# RADIOACTIVE LUMINOUS COMPOUNDS - PROTECTIVE MEASURES

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WAR DEPARTMENT,

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War Department Pamphlet No. 8-8, Radioactive Luminous Compounds—Protective Measures, is published for the information and guidance of all concerned.

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BY ORDER OF THE SECRETARY OF WAR:

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Chief of Staff.

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The Adjutant General.

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For explanation of symbols, see FM 21-6.



## CONTENTS

SECTION		Paragraph	Page
I. GENERAL.			
	Introduction .....	1	1
	Purpose .....	2	1
II. PHYSICAL CONSTRUCTION.			
	General requirements .....	3	2
	Equipment .....	4	2
	Ventilation .....	5	3
	Lighting .....	6	4
III. MAINTENANCE AND OPERATION.			
	Clothing and other protective wear .....	7	5
	Personal hygiene .....	8	5
	Plant and individual operating rules .....	9	6
	Compliance with rules .....	10	8
IV. MEDICAL AND ENGINEERING CONTROL.			
	Medical control .....	11	9
	Engineering control .....	12	10

(III)

# CONTENTS

## SECTION I. GENERAL

Introduction.....1  
 Purpose.....1

## II. PHYSICAL CONSTRUCTION

General requirements.....2  
 Equipment.....2  
 Ventilation.....2  
 Lighting.....2

## III. MAINTENANCE AND OPERATION

Clothing and other protective wear.....3  
 Personal hygiene.....3  
 Plant and individual operating rules.....3  
 Compliance with rules.....10

## IV. MEDICAL AND ENGINEERING CONTROL

Medical control.....11  
 Engineering control.....12



## SECTION I

### GENERAL

#### SECTION II

**1. INTRODUCTION.** The use of radium and radioactive compounds in industry is recognized as one of the most serious industrial health problems. Moreover, the use of radium-containing paints is widespread. It is highly important, therefore, that the most meticulous care be taken to prevent the occurrence of radium poisoning among both civilian employees and military personnel at United States Army installations.

**2. PURPOSE.** The purpose of this pamphlet is to formulate a set of rules for the safe handling of radium compounds in Army owned and operated industrial installations, and to present details of construction and the maintenance of necessary equipment used in radium processes.

## SECTION II

### PHYSICAL CONSTRUCTION

**3. GENERAL REQUIREMENTS. a. Required air spaces.** There will be a minimum of 100 square feet of floor space, and where more than four workers are engaged, there will be at least 25 square feet of floor space for each person in which radioactive luminous painting is being performed. Rooms will be as free as possible of ledges, surfaces, pipes, etc., on which dust may collect.

**b. Floor surfaces.** All floors in rooms in which radioactive luminous compounds are used or handled will have a smooth finish and a surface of water-repellent material with no cracks or crevices in which dust may collect.

**c. Wall, ceilings, and trim.** All walls, ceilings, and trim in rooms in which radioactive luminous compounds are used or handled will have a smooth surface with no cracks or crevices in which dust may collect. Such surfaces will have moisture-repellent qualities at least equal to those of a good quality oil paint.

**d. Lunchrooms.** There will be no door connecting any lunchroom with any room in which any radioactive luminous compounds are used or handled.

**e. Darkroom.** A darkroom with a minimum of 16 square feet of floor space and equipped with at least one argon bulb for personal inspection will be provided. At least one spare argon bulb will be available as a replacement at all times. This darkroom will be exhaust-ventilated at a rate equivalent to approximately 15 air changes per hour.

**f. Washing facilities.** Washing facilities will be adjacent to the darkroom and will include hot and cold running water, at least one wash basin for each five employees, soap and individual paper towels, sufficient waste receptacles to receive all refuse, and one nailbrush for each employee. Such wash basins will be used only for the purpose intended.

**4. EQUIPMENT. a. General.** All shelves, storage cabinets, drying cabinets, ovens, waste receptacles, trays for finished work, and racks which are used in any room in which radioactive luminous compounds are used or handled will be constructed throughout of material that is impervious



to moisture. All surfaces will be smooth and washable, and all corners will be rounded.

**b. Desks.** Desks used for the application or handling of radioactive luminous compounds will not have drawers, and will be free from ornamental trim or sharp corners. Desk tops will have a finish impervious to solvents or other chemicals used; otherwise, the tables will be finished throughout with a smooth, moisture-repellent coating.

**c. Chairs.** Chairs will have a smooth, moisture-repellent finish throughout, and will be provided with adjustable seats and back rests. Attached padding will have a smooth, washable surface throughout, and will not have cracks or crevices. The use of detachable pads or cushions will not be permitted.

**d. Waste receptacles.** Waste receptacles will be made of metal or other smooth, impervious material, and will have a foot-operated, self-closing lid.

**e. Individual paint and solvent crucibles.** Individual paint and solvent crucibles will have smooth glazed surfaces, will be mounted in bases sufficiently heavy to prevent accidental upsetting, will be as low as possible, and will be provided with covers so designed that the covers will not come into contact with the radioactive luminous compound. The covers will not be permanently attached to the crucibles. Such crucibles will be of sufficient size that the material will not overflow while being mixed.

**f. Stirring rods.** Stirring rods will be made of glass, metal, or other smooth impervious material, and will be sufficiently long so that there will be no possibility of contaminating the fingers.

**g. Brush-cleaning jars.** Brush-cleaning jars will be sufficiently short so there will be no possibility of contaminating the fingers during the cleaning of paint brushes.

**5. VENTILATION. a. General.** Ventilation will be provided in all rooms in which radioactive luminous compounds are used or handled, so, that the radon content of the air in the room will not exceed  $10^{-11}$  curie per liter.

**b. Local ventilation.** The following operations involving the use or handling of radioactive luminous compounds will be provided with local exhaust ventilation: weighing, compounding, bottling, application (painting), drying, baking, removing, and reclaiming radioactive luminous compounds (stripping). The design of exhaust hoods and the rate of air flow into them will be such that the radon content of the air breathed by workers does not exceed  $10^{-11}$  curie per liter. Air removed by the exhaust ventilation system will not be recirculated and will be discharged directly to the atmosphere.

**c. Local exhaust ventilation for application of radioactive luminous compounds.** Radioactive luminous compounds will be applied in a glass-topped work booth which is placed on the desk, and through which air is exhausted at a face velocity of at least 100 lineal feet per minute.

**d. Ventilation for storage and drying cabinets.** Cabinets in which painted dials are stored or dried will be ventilated at a minimum face

velocity of 100 lineal feet per minute. There will be a continuous flow of at least 360 cubic feet of air per minute per 1,000 dials stored.

**6. LIGHTING. a. General.** The intensity of light on the floor of every room in which radioactive luminous compounds are used or handled will be not less than 20 foot-candles. The intensity of light in washrooms, locker rooms, and toilet rooms will be not less than 10 foot-candles.

**b. Working plane.** The intensity of light on the working plane for persons required to use or handle radioactive luminous compounds will be not less than 50 foot-candles.

**c. Arrangement.** Artificial lighting units will be so arranged and shaded as to eliminate harmful shadows and glare for the operator.

**d. Workroom.** All rooms in which radioactive luminous compounds are used or handled will be so constructed that they may be easily darkened for the purpose of making inspections by means of ultraviolet light.

Individual paint and solvent containers will be stored in a designated area. Containers will have warning labels and will be stored in a way to prevent accidental overturning. To prevent accidental overturning, a rack will be provided with covers so designed that the covers will fit over the containers and the containers will be stored in contact with the radioactive luminous compounds. The covers will not be permanently attached to the containers. Such covers will be so designed that the material will not become wet during cleaning.

Painting tools will be made of glass, steel, or other suitable impervious material, and will be sufficiently long so that there will be no possibility of contaminating the paper.

Brush-cleaning jars will be sufficiently large so that there will be no possibility of contaminating the floor during the cleaning of paint brushes.

**7. VENTILATION. a. General.** Ventilation will be provided in all rooms in which radioactive luminous compounds are used or handled so that the volume of air in the room will not exceed 100 cubic feet per person.

**b. Local ventilation.** The following operations involving the use or handling of radioactive luminous compounds will be provided with local exhaust ventilation: weighing, compounding, filling, application, painting, drying, mixing, and reworking. The design of exhaust hoods and the rate of air flow shall be such that the total volume of air exhausted from the room shall not exceed 100 cubic feet per person. Air exhausted from the room shall not be recirculated and will be exhausted directly to the atmosphere.

**c. General exhaust ventilation for application of radioactive luminous compounds.** Radioactive luminous compounds will be applied in a room having a total volume which is equal to the room and storage volume. The room shall be exhausted at a rate of 100 cubic feet per person.

**d. Ventilation for storage and drying cabinets.** Cabinets in which painted dials are stored or dried will be ventilated in a room having



### SECTION III

## MAINTENANCE AND OPERATION

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**7. CLOTHING AND OTHER PROTECTIVE WEAR.** **a. Smocks.** Every person required to apply or handle radioactive luminous compounds will wear a smock while at work. These smocks will not have pockets and should close at the back. A freshly laundered smock will be issued to each employee at least twice a week.

**b. Storage of personal belongings.** Facilities for the storage of personal belongings will be provided for persons who apply or handle radioactive luminous compounds. Such facilities will be used exclusively for the storage of personal belongings, and will not be located in any room in which radioactive luminous compounds are used or handled. An individual locker is recommended for each person. Personal effects, such as purses, cosmetics, and handkerchiefs, will not be taken into the workroom.

**c. Soiled clothing.** Soiled work clothes will be deposited in hampers when a change of clothing is issued. Such hampers will be of sufficient capacity to receive all the soiled clothing.

**d. Laundering.** Soiled work clothes will be laundered without expense to the employees. Smocks will be inspected in ultraviolet light for contamination by radioactive luminous compounds, and all contaminated areas will be cleaned by an appropriate solvent prior to the laundering process.

**e. Supervision.** Distribution, maintenance, and inspection of protective wear will be supervised.

**8. PERSONAL HYGIENE.** **a. Inspection and cleaning after working hours.** Every person who handles or uses radioactive luminous compounds will examine himself under supervision under an argon bulb in a darkroom before lunch on termination of work each day. Deposits of such compounds found will be removed with an appropriate solvent and cleansing tissue. The soiled tissues will be deposited in waste receptacles which will be provided in the darkroom.

**b. Washing and final inspection.** After inspection and cleaning, every person will immediately wash with soap and warm water, after which he will return to the darkroom for reinspection under the argon



lamp, and any remaining radioactive substances will be removed. Such inspection and washing will be repeated until all radioactive substances have been removed. After the final washing before leaving, the hands of every employee will be inspected under the argon bulb by the person who supervises the observance of these rules by the employees.

**c. Inspection and cleaning during working hours.** Before leaving the workroom for any purpose, every employee will inspect his hands under the argon bulb, and will remove all radioactive substances by means of solvent and tissue.

**9. PLANT AND INDIVIDUAL OPERATING RULES. a. Supervision.** It will be the duty of the supervisor to enforce strictly these rules. The supervisor should be thoroughly informed of the nature of radium, the hazards associated with radioactive luminous materials, and the appropriate procedures for their safe handling and control.

**b. Prohibited methods of application.** Use of the dry method of applying radioactive luminous compounds, such as the dusting of material on adhesive or solvent, the silk-screen method, and the spray method will not be permitted.

**c. General plant maintenance.** All floors, walls, ceilings, trim, furniture, and equipment, including toilet and sanitary facilities of radium dial units, will be maintained in a clean and sanitary condition and in good repair.

**d. Floor maintenance.** Floors will be washed daily. Drysweeping of floors is prohibited.

**e. Plant inspection.** All rooms, furniture, work desks, cabinets, trays, racks, ovens, and washroom fixtures will be inspected with an argon bulb daily, and all deposits of radioactive luminous substances thus found will be removed immediately by means of an appropriate solvent.

**f. Dial painting workrooms—restrictions of use.** Workrooms in which radioactive luminous compounds are applied will not be used for any purpose other than dial painting and operations directly connected therewith. Spray painting of dials with black paint prior to the application of radioactive luminous compounds will not be permitted in the dial painting room. If the room in which spray painting is done is located next to the dial painting room, there will be no connecting door between the two rooms.

**g. Storage of radioactive luminous compounds.** Supplies of radioactive luminous compounds will at all times be stored in a suitable lead-lined container and at such a location that whole body exposure to gamma radiation will not exceed 0.1 roentgen unit per day.

**h. Scraping.** Operations involving the scraping of radioactive luminous compounds from articles preliminary to repairing or refinishing them will be performed by means of a wet process under running water or an appropriate solvent. If dry-scraping is necessary, it will be done in a glass cabinet with openings for the arms only and with down-draft local exhaust ventilation through a grille which will constitute the floor of the cabinet. Air will be drawn into the openings of the cabinet at a face velocity of not less than 500 lineal feet per minute. A shallow tray filled with water will be placed immediately beneath the exhaust grille.



**i. Mixing paint.** Mixing of radioactive luminous compounds will be done only in an exhaust-ventilated booth with openings for the arms, and air will enter the booth at a face velocity of 500 lineal feet per minute. Mixing will not be performed at the painting tables.

**j. Painting.** Painting will be done only under glass-topped work booths placed on individual tables. Air will be exhausted through these booths at a face velocity of at least 100 lineal feet per minute.

**k. Solvents.** Solvents to be used for cleansing purposes and as thinners will be issued to dial painters in stoppered bottles. The use of benzol in connection with the application of radioactive luminous compounds will not be permitted. Residues of radioactive luminous compounds in solvent or brush-cleaning bottles will be removed and discarded daily by pouring such residue into the sink and flushing with water.

**l. Pointing and wiping brushes and tools.** Every person required to use or handle radioactive luminous compounds will at all times be supplied with paper cleansing tissue. No method or material other than paper cleansing tissue will be used for wiping or pointing brushes, or other cleansing operations performed by the operator.

**m. Disposal of tissue.** Small (2- by 2- by 2-inch) cardboard boxes with attached covers will be used for disposal of wiping tissues. When these boxes are filled, or at the end of the working day, they will be closed and placed in a waste receptacle.

**n. Handling of radioactive luminous compounds.** Radioactive luminous compounds will be handled with care, so as not to be brought into contact with a person's body or clothing.

**o. Tool rack and trays.** A disposable brush or tool rack and a rack or tray for finished work will be provided for each person applying radioactive luminous compounds. Brushes and mixing tools will be kept on such racks at all times when not in actual use, and must not be placed directly on the table tops at any time. The rack will be disposed of daily, or oftener if necessary, by burning.

**p. Tools to be kept on top of table.** All tools and equipment, including brushes, mixing tools, vials, containers of solvents and crucibles, will be kept on top of the table at all times.

**q. Spilled material.** Spilled radioactive luminous compounds will be immediately removed with appropriate solvent and tissue.

**r. Finished work.** Finished work will be placed on a tray. Each tray will be removed to the dryer when full.

**s. Containers to be kept covered.** All containers of radioactive luminous compounds, whether full or empty, will be kept covered at all times, except while in actual use. Supply vials will be destroyed immediately after emptying, or will be collected and returned to the paint manufacturer. Containers will be stored at least 3 feet from the working area.

**t. Maintenance of desks.** Each dial painter will be required to clean his desk thoroughly at the end of the working day.

**u. Maintenance of tools.** All mixing rods, paintbrushes, spatulas, and other implements which have come in contact with radioactive luminous compounds will be thoroughly cleaned with an appropriate solvent at the end of each working day or oftener if necessary.

**v. Fluorescent paint.** Persons applying fluorescent compounds will observe all the procedures for applying radioactive luminous compounds.

**w. Smocks.** Smocks or other protective wear will not be worn during lunch or rest periods. No garments will be worn over smocks. Smocks will be worn at all times in the workroom, and will be kept at the work table when not being worn.

**x. Eating—where permitted.** No food, including chewing gum, candy, beverages, and tobacco, will be brought into radium dial rooms.

**y. Work restrictions.** Persons engaged in the handling or use of radioactive luminous compounds will not perform other duties until released by the supervisor.

**z. Handkerchiefs.** Cloth handkerchiefs will not be used. A supply of disposable tissue will be provided, and will be placed in the workroom in such a position as to prevent it from becoming contaminated.

**aa. Persons permitted in workrooms.** Unauthorized persons will not be permitted in workrooms where radioactive luminous compounds are used or handled. A notice to such effect will be posted on the entrance doors.

**ab. Training.** Persons will not be permitted to use or handle radioactive luminous compounds until they have been given thorough instruction in the nature of radium and the dangers in handling, and have received proper training in the approved techniques of dial painting. This training will stress the necessity of forming habits of scrupulous personal cleanliness. Persons who do not have or develop these habits will not be employed. Only compounds without radioactive materials will be used during the training period.

**10. COMPLIANCE WITH RULES.** The commanding officer of the installation or the plant operator will make certain that copies of the rules for maintenance and operation contained in section III will be extracted and posted in conspicuous form in the workroom. It will be the duty of the supervisor to see that these rules are obeyed. All employees will be required to observe these rules and any additional rules made.



## SECTION IV

### MEDICAL AND ENGINEERING CONTROL

**11. MEDICAL CONTROL. a. Tolerance.** The maximum allowable concentration of radon in the expired air of persons will be  $10^{-12}$  curie per liter.

**b. Physical examinations.** (1) *Preemployment examinations.* An examination will be made on applicants for employment at operations involving exposure to radioactive luminous materials. This examination will include the following special tests:

- (a) Determination of radon content of expired air.
- (b) Complete blood count.
- (c) X-ray of the chest.
- (d) Serology.

(2) *Periodic examinations.*

(a) Determination of radon content of expired air will be made at 6-month intervals.

(b) Complete blood counts will be at 6-month intervals.

**c. Conditions considered undesirable for operators handling radioactive luminous compounds.** (1) Radon concentrations in expired air of  $10^{-12}$  curie per liter or above.

- (2) Any significant abnormality in the blood picture.
- (3) Advanced pyorrhea and/or dental caries.
- (4) Other conditions considered undesirable by the examining physician.

**d. Method of collection of samples.** (1) *Routine breath samples.* The sample of expired air will be collected only when the individual has been removed from all exposures to radioactive materials for at least 8 hours. On the day scheduled for collection of the sample, the individual will report to the industrial medical officer prior to commencing work in the luminous paint unit. Collection of samples will be made in a place known to be free of radioactive materials. The individual will exhale into a regulation basketball bladder (or rubber balloon of approximately the same size) until the bladder is distended sufficiently to be free from wrinkles. Breathing during collection of the sample will be normal breathing (ordinary deep breathing at a moderate rhythm). The neck of the bladder will then be pushed on the end of the free glass tube of the

stopcock at the top of the flask supplied by the National Bureau of Standards, and the stopcock turned to the open position. This stopcock should not, under any conditions, be turned until the bladder is connected. After an interval of approximately 15 seconds, the stopcock will be turned to the closed position, and the flask prepared for shipment to the National Bureau of Standards, Washington, D. C. Samples should not remain in the rubber bladder longer than necessary to effect the transfer of the expired air sample to the flask, since rubber slowly absorbs radon.

(2) *Recheck of breath samples.* The procedure will be identical with that described for collection of routine breath samples except that the sample will be collected only when the individual has been removed from all exposures to radioactive materials for 1 week.

**e. Procedure for handling persons showing excess radon concentrations.** (1) *Testing.* Persons whose expired air shows a concentration of  $10^{-12}$  curie or more per liter will immediately be removed from all exposure to radioactive materials and will be retested at the expiration of 1 week.

(2) *Removal from work.* Persons whose expired air shows a radon concentration of  $10^{-12}$  curie or more per liter based on two samples will be immediately transferred to work which will not involve exposure to radioactive materials.

(3) *Reemployment.* Persons who have had prior exposure to radioactive materials will not be reemployed until an expired air sample has been obtained, the radon concentration of which must be below  $10^{-12}$  curie per liter. Determinations of radon in expired air of such reemployed persons will be made at 1-month intervals.

**f. Report of tests.** The results of expired air tests will be reported promptly to the individual concerned by the Industrial Medical Officer.

**g. Discontinuance of work.** An expired air sample will be collected from each person on discontinuance from work involving exposure to radioactive luminous compounds.

**h. Records.** Accurate records of working time, duties, amounts of radioactive luminous compounds handled or used, and other pertinent information will be kept for all persons.

**i. Data card.** The data card which accompanies the expired air sample container will be completely filled in and will accompany the sample flask.

**12. ENGINEERING CONTROL.** **a. Tolerance.** The radon content of workroom air will not exceed  $10^{-11}$  curie per liter. Determinations of the radon content will be made at 6-month intervals or oftener, if required.

**b. Methods of collection of samples.** The small paper label will be removed from the end of the filter tube which accompanies the sample flask and the filter tube attached to the inlet tube of the flask. The stopcock on the top of the flask will be turned to the open position at the location in the room where the sampling is desired. After the air in the flask has come to atmospheric pressure, the stopcock will be turned to the



closed position, and the flask prepared for shipment to the National Bureau of Standards, Washington, D. C.

c. **Gamma radiation.** Whole body exposure to gamma radiation will not exceed 0.1 roentgen unit per working day.

d. **Gamma radiation determination.** If the minometer is used for the measurement of gamma radiation from radioactive luminous compounds, the ionization chambers will be shielded against beta radiation by  $\frac{1}{16}$  inch of lead (or equivalent) and the instrument recalibrated before use.

e. **Inspections.** The industrial hygiene engineering officer will make frequent unannounced inspection of all operations involving the use or handling of radioactive luminous compounds.



